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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventor: Tatau NISHINAGA Group Art Unit: 1765  
Appln. No.: 09/511,912 Examiner: M. Anderson  
Filed: February 23, 2000  
For: A METHOD FOR FORMING A SINGLE CRYSTALLINE FILM

RESPONSE UNDER 37 CFR § 1.116

Assistant Commissioner of Patents  
Washington, D.C. 20231

Sir:

In response to the Final Rejection dated February 13, 2003, Applicant respectfully requests reconsideration and allowance in light of the following remarks.

At the outset, Applicant wishes to thank the Examiner for the courtesy extended to his representative during a personal interview conducted on March 18, 2003. A summary of the issues discussed during this interview is included in the following discussion.

Claims 7-10 and 19 have been withdrawn from consideration.

Claims 1-6, 11-18, and 20-23 stand rejected under 35 USC §103(a) as being unpatentable over Tanaka et al. (US 6,377,596) in view of Tokunaga et al. (US 5,425,808) and Nakamura et al. (JP 01-234389A). Applicant respectfully traverses these rejections.

Claim 1 recites:

A method for forming a single crystalline film  
comprising the steps of:

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*forming an amorphous film on a single crystalline substrate,*

*forming an opening in the amorphous film and thereby exposing a part of a surface of the substrate, and*

*introducing atomic beams, molecular beams or chemical beams onto the surface of the substrate at their incident angle of not more than 40 degrees with respect to the substrate surface under a reduced atmosphere and thereby selectively and epitaxially growing a single crystalline film on the exposed surface of the substrate.*

The Office Action states that Nakamura discloses a molecular ray method of performing epitaxy wherein the angle of incidence between the substrate and the molecular beam can be optimized between zero and 90 degrees (Office Action, page 4, 2<sup>nd</sup> paragraph). Continuing, the Office Action proposes that it would have been obvious to combine the teachings of Nakamura with those of Tanaka and Tokunaga because optimizing the angle of incidence between the beam and the substrate surface during the lateral overgrowth would have anticipated results (Office Action, page 4, 4<sup>th</sup> paragraph).

However, Nakamura discloses in Figs. 1 and 2 that epitaxial growth is optimized when a molecular beam from source 2 strikes a substrate 6 at an angle perpendicular to its surface. Additionally, these figures illustrate that the rate of epitaxial growth decreases as the angle at which the molecular beam strikes the substrate surface decreases from 90 degrees to zero degrees.

By contrast to the teachings of Nakamura, Applicant's claimed method achieves an increasing amount of epitaxial lateral

overgrowth as the angle at which the molecular beam strikes the substrate surface decreases from 90 degrees toward zero degrees. In an exemplary but non-limiting embodiment of Applicant's invention, illustrated by Figs. 1-3, the molecular beam particles 6-1 and 6-3 that impinge on amorphous film 2 are entirely reflected, or nearly so, with few if any of the particles being deposited on amorphous film 2 (Specification, page 3, lines 16-19). The molecular beam particles 6-2 impinging on an exposed surface 1A of single crystalline substrate 1, through opening 3, are almost entirely deposited without any being reflected (Specification, page 3, lines 19-21).

Referring now to application Fig. 2, as particles 6-2 continue to be deposited in opening 3, the deposited single crystalline film 7 grows up and out of opening 3 such that its upper surface 7a is higher than the upper surface of the surrounding amorphous film 2 (Specification, page 3, lines 23-25). Also, side surface 7B of the deposited film 7 becomes exposed to the molecular beam.

With side surface 7B exposed, molecular beam particles 6-5 impinging on side surface 7B begin to deposit on single crystalline film 7 without being reflected (Specification, page 3, line 27, through page 4, line 3). As illustrated in Fig. 3, a lateral single crystalline film 9 grows laterally overtop of amorphous film

2 as the epitaxial growth continues on side surface 7B (Specification, page 4, lines 6-8).

As stated in the Office Action, Nakamura discloses optimizing the angle of incidence between the substrate and the molecular beam to positively affect the product (Office Action, page 4, 3<sup>rd</sup> paragraph). As illustrated in Figs. 1 and 2, Nakamura discloses that the product is increasingly positively affected by reducing the angle between the molecular beam and an angle perpendicular to the substrate surface. Additionally, Nakamura discloses that the optimal positive effect on the product is achieved by directing the molecular beam perpendicular to the substrate's surface.

The epitaxial lateral overgrowth provided by Applicant's method of claim 1 is incapable of being achieved by a molecular beam directed perpendicularly to the substrate surface. This is because the molecular beam particles would be directed along an axis that is parallel to side surface 7B. Thus, the particles would never strike side surface 7B to produce the lateral epitaxial overgrowth of amorphous layer 2.

Combining the teachings of Nakamura with those of Tanaka and Tokunaga in the manner proposed in the Office Action for obtaining the optimal crystal would render the proposed method unsatisfactory for, if not entirely incapable of achieving, its intended purpose. If the proposed modification would render the prior art invention

being modified unsuitable for its intended purpose, then there is no suggestion or motivation to make the proposed modification. See MPEP §2143.01, 1<sup>st</sup> paragraph of 5<sup>th</sup> major heading; see also *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

In short, Nakamura teaches away from the claimed feature of introducing atomic, molecular, or chemical beams onto the surface of a substrate at an incident angle of not more than 40 degrees with respect to the substrate surface. Instead of the claimed feature, Nakamura teaches that 90 degrees is the optimal angle for epitaxial growth. Proceeding contrary to accepted wisdom in the art is evidence of nonobviousness. See MPEP §2145(X)(D)(3); see also *In re Hedges*, 783 F.2d 1038, 228 USPQ 685 (Fed. Cir. 1986).

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura, either alone or in combination, fail to disclose or suggest all of the instant claimed features. Specifically, the combined references fail to provide the suggestion or motivation to introduce atomic, molecular, or chemical beams onto the surface of a substrate at an incident angle of not more than 40 degrees with respect to the substrate surface, as claimed by Applicant. Therefore, allowance of claim 1 and all claims dependent therefrom is warranted.

Furthermore, as illustrated in the exemplary but non-limiting embodiment of Fig. 3, the dislocations generated in the single

crystalline films 4 and 7, from the lattice mismatch between substrate 1 and films 4 and 7, propagate in a direction almost perpendicular to the surface of substrate 1, and not in a direction parallel to the surface (Specification, page 4, lines 9-13). Thus, the single crystalline film 8 may have dislocations, but the single crystalline film 9 formed laterally on amorphous film 2 has very few dislocations (Specification, page 4, lines 13-16).

In several exemplary but non-limiting examples of Applicant's process, the single crystalline film 9 formed laterally on amorphous film was characterized by a transmission electron microscope as having a dislocation density of not more than  $10^2 \text{ cm}^{-2}$  (Specification, page 11, lines 23-25, page 12, lines 7-9, lines 18-19, lines 27-28, page 13, lines 21-23, page 14, lines 6-8, page 15, lines 2-4, and page 15, line 27, through page 16, line 1). By contrast to Applicant's superior results, Tanaka discloses a dislocation density in the range of  $10^4$  to  $10^5 \text{ cm}^{-2}$  (col. 4, lines 27-29).

"Evidence that a compound is unexpectedly superior in one of a spectrum of common properties ... can be enough to rebut a *prima facie* case of obviousness." *In re Chupp*, 816 F.2d 643, 646, 2 USPQ2d 1437, 1439 (Fed. Cir. 1987); MPEP §716.02(a), 1<sup>st</sup> paragraph of 2<sup>nd</sup> major heading.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura fail to teach or suggest the benefits accruing from the instant claimed combination. Therefore, allowance of claim 1 and all claims dependent therefrom is warranted for this independent reason.

Dependent claim 17 recites introducing atomic, molecular, or chemical beams onto the surface of a single crystalline substrate to grow a single crystalline film on the exposed surface of the substrate. Additionally, claim 17 recites that the single crystalline substrate and single crystalline film are of different materials.

The Office Action states that Tanaka discloses growing single crystalline GaN on a single crystalline sapphire substrate using an epitaxial lateral overgrowth (ELO) technique (Office Action, page 5, 3<sup>rd</sup> paragraph). The Office Action acknowledges that Tanaka does not disclose molecular beam epitaxy (MBE) as the method of GaN semiconductor growth (Office Action, page 3, 3<sup>rd</sup> paragraph). Continuing, the Office Action states that Tokunaga discloses laterally overgrowing GaAs on an amorphous film (Office Action, page 3, 4<sup>th</sup> paragraph). Additionally, the Office Action states that Tokunaga suggests the equivalence of MBE and chemical vapor deposition (CVD) for the growth of epitaxial films (Office Action, page 3, 4<sup>th</sup> paragraph). Based on this information, the Office

Action proposes that it would have been obvious to combine the references because Tokunaga suggests an equivalent method of growing selective epitaxial nitride films upon amorphous masking layers (Office Action, page 3, 5<sup>th</sup> paragraph).

While Tokunaga may suggest the interchangeability of MBE and CVD in the process of forming "a thin film by photolithography of the prior art," Tokunaga does not suggest their interchangeability for epitaxially growing a single crystalline film of one material on a single crystalline substrate of a different material (see Tokunaga col. 1, lines 24-33, for the above quoted text). To the contrary, Tokunaga discloses that "selective deposition methods are known in which a monocrystal substrate is covered partially with an amorphous thin film, and the same material as the substrate is epitaxially grown only at the exposed portion of the monocrystal substrate" (col. 2, lines 13-17). "[T]hese selective deposition methods rely on growing selectively the monocrystal semiconductor of the same kind from the exposed surface of the monocrystal substrate" (emphasis added) (col. 2, lines 28-31). Therefore, Tokunaga teaches away from the claimed combination recited in claim 17. It is improper to combine references where the references teach away from their combination. See MPEP §2145(X)(D)(2); see also *In re Grasselli*, 713 F.2d 731, 743 218 USPQ 769, 779 (Fed. Cir. 1983).



Claim 18 more definitely recites the features of: (1) forming the single crystalline film on the surface of the single crystalline substrate, and (2) forming the single crystalline substrate and the single crystalline film using different materials. This claim states that the single crystalline film and a surface layer of the single crystalline substrate, upon which the single crystalline film is formed, have different molecular structures.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura, either alone or in combination, fail to disclose or suggest all of the features of claims 17 and 18. Specifically, the combined references fail to provide the suggestion or motivation to introduce atomic, molecular, or chemical beams onto the surface of a substrate to form a single crystalline film of a first material, or molecular structure, on the surface of a single crystalline substrate of a different material or molecular structure, as claimed by Applicant. Therefore, allowance of claims 17 and 18 and all claims dependent therefrom is warranted.

With regard to claims 20-23, the Office Action states that it would have been obvious to one of ordinary skill in the art to use GaAs as the single crystalline film and sapphire as the single crystal substrate because sapphire or GaAs substrates were known by

Tanaka for use in selective epitaxy of III-V semiconductors of which GaAs and GaN are well known examples (Office Action, pag 5, last paragraph). This is the only basis provided by the Office Action in support of the rejections to claims 20-23.

In rejecting claims for want of novelty or for obviousness, the examiner must cite the best references at his or her command. When a reference is complex or shows or describes inventions other than that claimed by the applicant, the particular part relied on by the examiner must be designated as nearly as possible. 37 CFR §1.104(c)(2).

A brief inspection of Tanaka's 34-column specification and nineteen sheets of drawings provides overwhelming support for a conclusion that this reference is extremely complex. The Office Action does not cite any particular part of Tanaka in support of the obviousness rejections to claims 20-23. Therefore, the evidentiary record fails to adequately support a *prima facie* case of obviousness.

Moreover, regardless of whether GaAs and GaN are well known examples of III-V epitaxial semiconductor films and whether sapphire or GaAs substrates were known to Tanaka, these statements alone fail to suggest the claimed combination. Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaAs,  $Ga_{1-x}Al_xAs$ , ZnSe, ZnS, CdTe,  $ZnS_{1-x}Se_x$ , or YBCO

onto the surface of a substrate of Si, GaAs, ZnSe, SrTiO<sub>3</sub>, or sapphire and (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, as recited by claim 20.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaN, GaAs, Ga<sub>1-x</sub>Al<sub>x</sub>As, ZnSe, ZnS, CdTe, ZnS<sub>1-x</sub>Se<sub>x</sub>, or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, or SrTiO<sub>3</sub>, and (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, as recited by claim 21.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaAs, Ga<sub>1-x</sub>Al<sub>x</sub>As, ZnSe, ZnS, CdTe, ZnS<sub>1-x</sub>Se<sub>x</sub>, or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, SrTiO<sub>3</sub>, or sapphire, (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, and (3) forming a single crystalline film of a first molecular structure on the surface of a single crystalline substrate of a different molecular structure, as recited by claim 22.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaN, GaAs, Ga<sub>1-x</sub>Al<sub>x</sub>As, ZnSe, ZnS, CdTe, ZnS<sub>1-x</sub>Se<sub>x</sub>, or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, or SrTiO<sub>3</sub>, (2) introducing the beam at an incident angle of

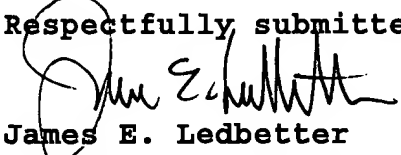
not more than 40 degrees with respect to the substrate surface, and  
(3) forming a single crystalline film of a first molecular structure on the surface of a single crystalline substrate of a different molecular structure, as recited by claim 23.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura, either alone or in combination, fail to disclose or suggest all of the features of instant claims 20-23. Furthermore, Applicant submits that the evidentiary record fails to support a *prima facie* case of obviousness regarding these claims. Therefore, allowance of claims 20-23 is warranted.

In view of the above, it is submitted that this application is in condition for allowance and a notice to that effect is respectfully solicited.

If any issues remain which may best be resolved through a telephone communication, the Examiner is requested to telephone the undersigned at the local Washington, D.C. telephone number listed below.

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